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STATUS OF STOCKS OF SPINY AND SLIPPER LOBSTERS IN THE NORTHWESTERN HAWAIIAN ISLANDS, 1986

Jeffrey J. Polovina, Robert B. Moffitt, and Raymond P. Clarke
Southwest Fisheries Center Honolulu Laboratory
National Marine Fisheries Service, NOAA
Honolulu, Hawaii 96822-2396

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OVERVIEW

Research and commercial data are used to assess the status of the slipper and spiny lobster fishery in the Northwestern Hawaiian Islands in 1986. 1) At Necker Island female spiny lobsters are now first bearing eggs at a significantly smaller size than they were in 1977. It is presumed that this decrease in size of the onset of sexual maturity is in response to fishing pressure. 2) Since 1984, catch rates of sublegal spiny lobsters have declined signficantly at Necker Island presumably due to capture and release mortality. The decline in sublegal catch rates at Necker Island corresponds to declines in legal spiny catch rates for subsequent years. The use of escape vents in traps offers a means of reversing the decline of sublegal catch rates. 3) In general the spiny lobster stocks appear in good condition. The female spawning stock biomass estimates for at Necker Island and Maro Reef are 36 and 58%, respectively, of their levels prior to exploitation. With the use of escape vents it appears that the current level of annual landings of about 900,000 lobsters is sustainable. The slipper lobster fishery is only in its second year of heavy exploitation and current yields are not equilibrium yields. The maximum sustainable yield (MSY) for slipper lobsters is estimated at 600,000 lobsters or about one-half the 1986 landings. Thus an MSY for the combined spiny and slipper lobster fishery is estimated at 1.5 million lobsters.

INTRODUCTION

In July 1986 the NOAA ship Townsend Cromwell conducted the second annual standardized lobster assessment cruise. During this cruise trapping for lobsters was conducted at selected sites at Necker Island, Maro Reef, and Laysan Island which were fished in 1977 and again in 1985. A standardized trapping gear based on the 2 x 4 in. wire mesh two chambered California style traps was employed for the sampling in 1977, 1985, and 1986. This report will compare the results of the 1986 cruise with those from 1977 and 1985.

SPINY LOBSTER ASSESSMENT FROM RESEARCH CRUISE DATA

In 1977, the commercial fishery for spiny lobsters was just beginning and effort was low. Catch rates from the research cruises in 1977 reflect the unexploited standing stock. Standardized catch rates for all trappable spiny lobsters for 1977, 1985, and 1986 at Necker Island, Maro Reef, and Laysan Island are presented in Table 1 together with comparisons of the 1985 and 1986 catch rates relative to those of 1977. The catch rates for all trappable lobsters in 1986 are 33, 53, and 56% of their level in 1977 at Necker Island, Maro Reef, and Laysan Island, respectively. The declines at Necker Island and Maro Reef are statistically significant while due to the large variation in catch rates around Laysan there is not a statistically significant difference in the catch rates at Laysan between 1977 and 1986. For all three regions the catch rates are slightly lower in 1986 than in 1985 but in none of the cases is this apparent decline statistically significant.

Table 1.--Mean CPUE (lobsters/trap-night) of all spiny lobsters from wire traps. (SE = standard error.)

Island/Bank	1977	1985	1986	1985/1977	SE	1986/1977	SE
Necker Island	6.30	2.52	2.08*	0.40	--	0.33	(0.03)
Maro Reef	3.29	2.07*	1.74*	0.63	(0.09)	0.53	(0.07)
Laysan Island	2.64	1.63	1.48	0.62	(0.36)	0.56	(0.24)

*Significantly less than the 1977 CPUE at the 5% level.

Necker Island and Maro Reef are heavily fished and it is expected that these regions would show a significant decline in trappable catch rates since 1977, while Laysan Island is a refuge and is not fished. The statistically significant decline in catch rates at Necker Island and Maro Reef will be examined in more detail for two size classes--harvestable and subharvestable lobster.

There have been several management measures which define the minimum size of spiny lobster which can legally be harvested over the period covered by the sampling in 1985 and 1986 with the most recent and current regulation adopted in 1986 which permits the harvesting of lobsters without eggs if they have a tail width equal to or exceeding 5.0 cm. However, since most of the fishing pressure during the years 1985 and 1986 targeted lobsters with a carapace length equal to or exceeding 7.7 cm (5.1 cm tail width) catch rates for lobsters equal or exceeding 7.7 cm carapace length will be used as a measure of the relative abundance of the harvestable population. Since the wire mesh traps rarely capture lobsters with a carapace length less than 7.0 cm, an estimate of the relative abundance of the subharvestable population will be measured as the catch rate of lobsters with carapace lengths from 7.0 to 7.7cm (4.7 to 5.1 cm tail width).

The standardized catch rates of our harvestable size class lobsters in 1986 are 22 and 49% of their 1977 levels at Necker Island and Maro Reef, respectively (Table 2). There is an apparent decrease in legal catch rates from 1985 to 1986 but it is not a statistically significant decline. The standardized catch rates of our subharvestable size class lobsters has declined in 1986 to 48 and 85% of their 1977 levels at Necker Island and Maro Reef, respectively (Table 3). This decline at Necker Island is statistically significant while that at Maro Reef is not.

Table 2.--Mean CPUE (lobster/trap-night) for lobsters with carapace length equal to or exceeding 7.7 cm. (SE = standard error.)

Island/Bank	1977	1985	1986	1985/1977	SE	1986/1977	SE
Necker Island	4.92	1.28	1.08*	0.26	--	0.22	(0.05)
Maro Reef	2.93	1.49*	1.44*	0.51	(0.11)	0.49	(0.07)

*Significantly less than the 1977 CPUE at the 5% level.

Table 3.--Mean CPUE (lobster/trap-night) for lobsters with carapace length between 7.0 and 7.7 cm. (SE = standard error.)

Island/Bank	1977	1985	1986	1985/1979	SE	1986/1977	SE
Necker Island	1.27	0.94	0.61*	0.74	--	0.48	(0.07)
Maro Reef	0.37	0.34	0.32	0.92	(0.14)	0.85	(0.16)

*Significantly less than the 1977 CPUE at the 5% level.

The size of the onset of sexual maturity of a population is often defined as the size at which 50% of the population is sexually mature. As an indicator of sexual maturity for female lobsters the presence or absence of external eggs is recorded for each female collected on the research cruises. The ratio of egg bearing females to the total number of females trapped during a cruise expressed as a function of the female size class follows an "S-shaped" curve taking the value of zero for small females, rapidly increasing over a short range of female size, and the remaining constant over a range of large animals (Fig. 1). While lobsters are found to be egg bearing over a broad summer and fall period, for the purposes of standardizing comparisons between years only data from the months of July and August were used. The size of onset of sexual maturity for female lobsters can be defined as the size where the ratio of egg bearing females to total females is one half the value for large females. Based on this approach it is estimated that in 1977, 50% of the females were sexually mature at a carapace length of 6.6 cm (4.5 cm tail width) or 67% of their asymptotic length at Necker Island and 7.6 cm (5.1 cm tail width) or 66% their asymptotic length at Maro Reef (Table 4). The estimated size of onset of sexual maturity at Necker Island and Maro Reef showed no significant difference between 1985 and 1986 and the data for the 2 years were combined within bank. For the pooled 1985 and 1986 data the size of onset of sexual maturity at Necker Island is estimated at 5.9 cm (4.1 cm tail width) or 59% of the asymptotic size while for Maro Reef the size of female sexual maturity is estimated at 7.1 cm (4.8 cm tail width) or 62% of the asymptotic size. Only the decline in the size of onset of sexual maturity at Necker Island is statistically significant. It is also interesting to note that the ratio of egg bearing females to total females reaches a constant level of 0.30 for large females in 1985-86 but only reached a constant level of 0.20 in 1977. Thus at Necker Island it appears that by 1985-86 the spiny lobster population was responding to fishing pressure with animals bearing eggs at a smaller size and perhaps a greater fraction of the females bearing eggs at any one time as well.

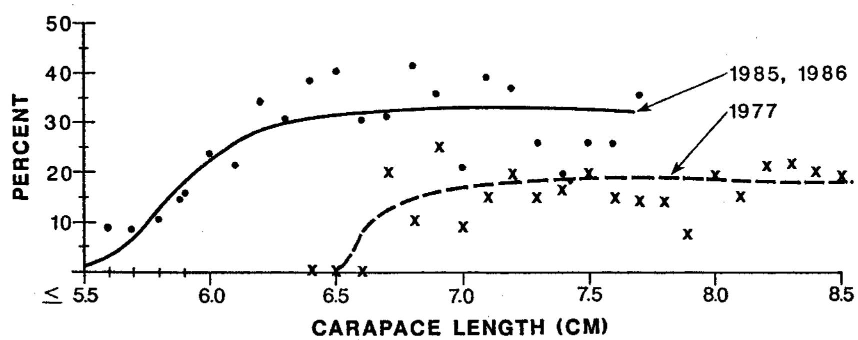

Figure 1.--Percent of females spiny lobsters at Necker Island with eggs by carapace length for 1977 and combined 1985 and 1986 samples all collected in months of July and August.

Table 4.--Size at which 50% of female population are estimated to be sexually mature for 1977 and 1985-86. (CL = carapace length, TW = tail width, LM/L∞ = ratio of length at maturity to asymptotic length, SE = standard error.)

Island/ Bank	1977 CL (cm)	SE	TW (cm)	LM/L∞	1985-86 CL (cm)	SE	TW (cm)	LM/L∞
Necker Island	6.6	(0.24)	4.6	0.67	5.9	(0.10)	4.1	0.59
Maro Reef	7.6	(0.26)	5.2	0.66	7.1	(0.13)	4.8	0.62
Laysan Island	8.3	(0.18)	5.6	0.70	7.8	(0.16)	5.3	0.66

Based on the estimates of sizes of the onset of sexual maturity and catch rates converted from numbers to weight per trap night, estimates of an index of the female spawning stock biomass is computed (Table 5). The female spawning stock biomasses in 1986 are 36 and 58% of their 1977 levels at Necker Island and Maro Reef, respectively. Both these declines are statistically significant. Under the widely used logistic surplus production model, the MSY is achieved when the population biomass has been reduced to 50% of its unexploited level.

Table 5.--Female spawning stock biomass CPUE (kg/trap-night). (SE = standard error.)

Island/Bank	1977	1985	1986	1985/1977	SE	1986/1977	SE
Necker Island	2.68	0.98	0.96	0.37	--	0.36*	(0.05)
Maro Reef	1.81	1.10	1.04	0.61*	(0.14)	0.58*	(0.16)
Laysan Island	1.53	1.36	1.32	0.89	(0.36)	0.86	(0.24)

*Significantly less than 1.0 at the 5% level.

SLIPPER AND SPINY LOBSTER ASSESSMENT WITH COMMERCIAL LOGBOOK DATA

Commercial lobster catch and effort data has been collected since 1983 as mandated by the Spiny Lobster Fishery Management Plan (Table 6). In 1984 the lobster fishermen began changing the type of traps used. The new traps caught slipper lobsters which previously were rarely caught in the old gear and in 1985 and 1986 the catches of slipper lobsters were about as large as those for spinys. The commercial catch data reports both spiny and slipper lobster catches but reports only the total trapping effort for all lobster catches rather than specifically the fishing effort which targets slipper lobsters and the effort which targets spiny lobster. However, for 1985 and

1986 a standardized measure of spiny lobster fishing effort can be computed by dividing the commercial catches by the research catch rate. This effort measure is in units of trap-nights for the wire mesh California traps--the same traps that were used commercially in 1983 and most of 1984. Thus by using the standardized effort computed from commercial landings and research catch rates in 1985 and 1986 it is possible to obtain an effort measure for 1985 and 1986 which is reasonably comparable to the commercial effort measure for spiny lobsters in 1983 and 1984. The fishing effort associated with spiny lobster landings in this report will always be this standardized effort, while the fishing effort associated with the combined slipper and spiny landings will be the actual commercial effort as recorded in the logbooks.

Table 6.--Commercial spiny and slipper lobster landings (in 1,000's of lobsters) and commercial and standardized effort (in 1,000's of trap-nights) for 1983-86.

Year	Area	Landings[1]			Total effort[1]	Spiny standardized effort[2]
		Legal spiny	Slipper	Total		
1983	Necker Island	112	14	126	48	48
	Maro Reef	27	9	36	16	16
	NWHI	158	26	184	77	77
1984	Necker Island	210	77	287	98	98
	Maro Reef	250	84	334	143	143
	NWHI	667	285	952	377	377
1985	Necker Island	186	154	340	211	145
	Maro Reef	360	538	898	372	242
	NWHI	955	1,190	2,145	1,081	772
1986	Necker Island	174	84	258	242	161
	Maro Reef	350	477	827	491	243
	NWHI	896	1,238	2,134	1,456	802

[1]Landings and total effort from Pooley et al. (1987).

[2]Spiny lobster standardized effort in 1983, 1984 is commercial effort which used wire traps and predominantly fished spiny lobster. Effort in 1985, 1986 for Necker Island and Maro Reef is computed as the ratio of commercial catches to research CPUE. Total NWHI effort in 1985-86 is computed as commercial effort multiplied by

$$\left(\frac{\text{Necker and Maro standardized effort}}{\text{Necker and Maro commercial effort}}\right)$$

In April 1986, the Honolulu Laboratory estimated that the MSY of spiny lobsters at Necker Island, Maro Reef, and the entire Northwestern Hawaiian Islands (NWHI) were 242,000, 360,000, and 896,000 lobsters, respectively. The 1986 commercial landings plotted with standardized effort are close to these levels (Figs. 2-4; Table 6). The yield at Necker Island reached a maximum in 1984 at a level of 210,000 lobsters and has declined as standardized effort increased in 1985 and 1986 to the 1986 level of 174,000 lobsters. At Maro Reef there was very little change the standardized effort and landings from 1985 to 1986 with 1986 landings at 350,000 lobsters. The situation was similar for the entire NWHI with 1986 landings of 896,000 lobsters which was down slightly from 1985 with a slight increase in standardized effort.

At Maro Reef, based on the yield curve and the relative level of female spawning stock biomass which is 58% of its level prior to the fishery, it appears that fishing effort and yield are sustainable and near optimum. At Necker Island the yield curve suggests that fishing pressure is excessive and the yield is below optimum. The relative level of female spawning stock biomass at Necker Island in 1986 is 36% of the level prior to the start of the fishery which is lower than that at Maro Reef and below the target level of 50% but perhaps not critical from the standpoint of recruitment overfishing. More revealing is the decline in sublegal catch rates observed in both commecial and research data at Necker Island (Fig. 5; Table 7). Since 1984 sublegal catch per unit of standardized effort (CPUE) estimated from commercial logbooks at Necker Island has declined. Research data in 1985 and 1986 support this trend. At Maro Reef the catch rates of sublegals are much lower than at Necker Island and research data shows no change while commercial logbook data suggests an increase. We

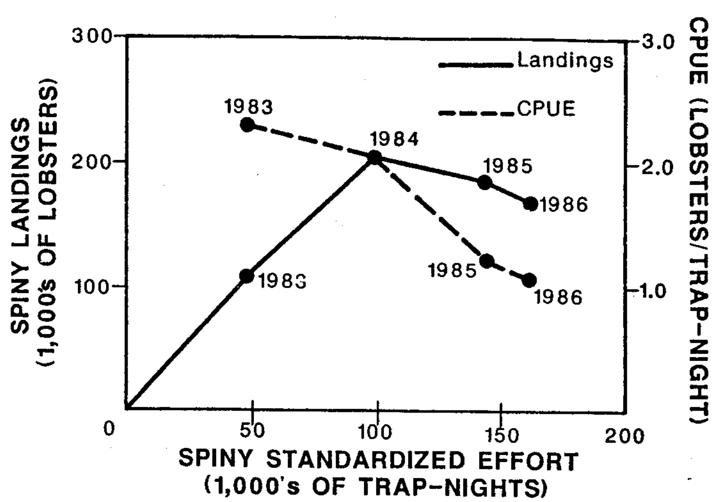

Figure 2.--Landings of spiny lobster, spiny standardized effort, and standardized CPUE for Necker Island, 1983-86.

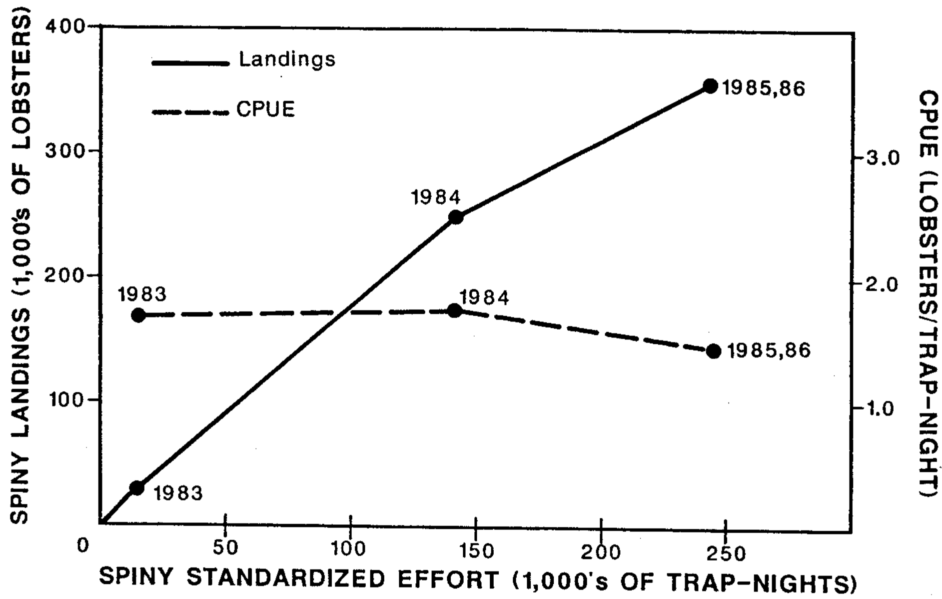

Figure 3.--Landings of spiny lobster, spiny standardized effort, and standardized CPUE for Maro Reef, 1983-86.

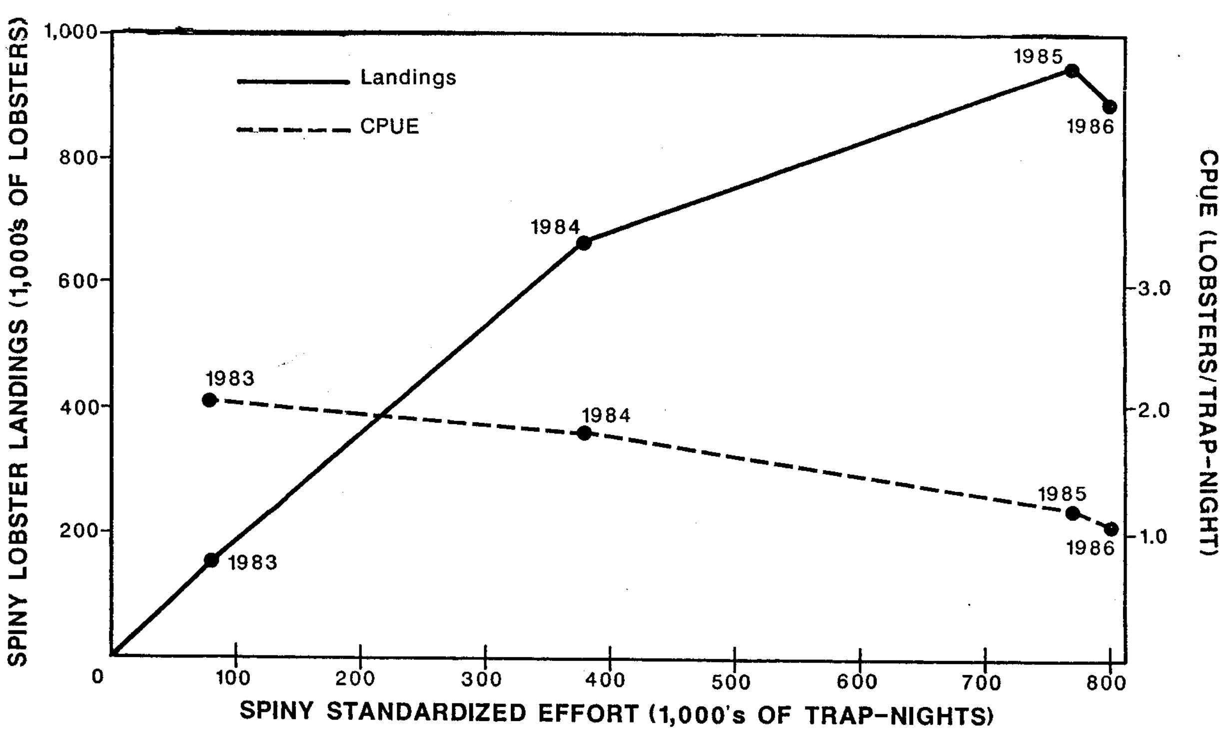

Figure 4.--Landings of spiny lobster, spiny standard effort, and standardized CPUE for NWHI, 1983-86.

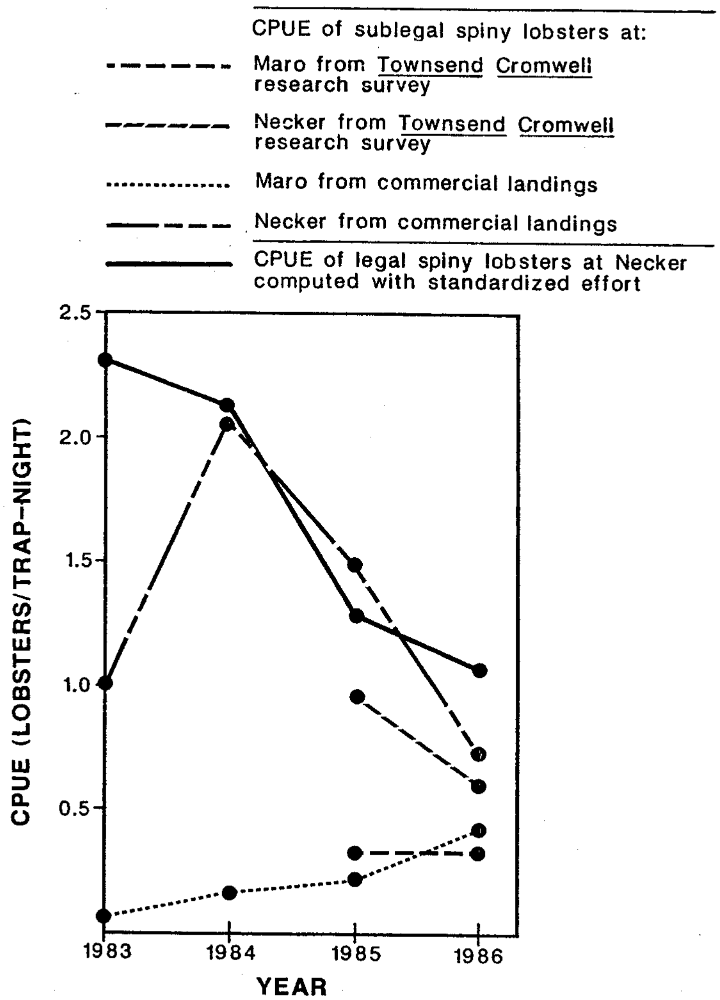

Figure 5.--Sublegal spiny lobster CPUE from commercial and research data for Maro Reef and Necker Island, and legal spiny standardized CPUE for Necker Island.

hypothesize that initially as fishing begins and large animals are removed, density dependent and behavioral factors could produce an increase in the sublegal CPUE as was initially observed at Necker Island and is the trend at Maro Reef. However, at Necker Island where the sublegal CPUE is as large as the legal CPUE, if capture and release mortality due to handling, exposure, predation, and displacement is significant, then the fishery is inducing mortality on the sublegal population. As fishing effort increased from 1984 to 1986 sublegal CPUE declined consistent with this hypothesis. The decline in legal CPUE since 1984 may be directly related, at least to some extent, to the decline in sublegal CPUE in prior years, since a reduction in the sublegal population may translate into a decline in the legal population. The extent that density dependent factors affect the sublegal to legal relationship is not known. However, the continued decline in sublegal CPUE in 1986 suggests that 1987 legal CPUE will be lower than 1986 legal CPUE. The use of escape vents can stop the decline

Table 7.--Catch (in 1,000's of lobsters), standardized effort (in 1,000's of trap-nights) and CPUE (lobster/trap-night) for sublegal lobsters.

Year	Area	Sublegal spiny catches	Spiny standardized effort	Commercial sublegal CPUE[1]	Townsend Cromwell sublegal CPUE
1983	Necker Island	48	48	1.00	NA
	Maro Reef	1	16	0.06	NA
	NWHI	51	77	0.66	NA
1984	Necker Island	207	98	2.11	NA
	Maro Reef	21	143	0.15	NA
	NWHI	238	377	0.63	NA
1985	Necker Island	213	145	1.47	0.94
	Maro Reef	54	242	0.22	0.34
	NWHI	345	772	0.45	NA
1986	Necker Island	119	161	0.74	0.61
	Maro Reef	105	243	0.43	0.32
	NWHI	308	802	0.38	NA

[1]Sublegal catches reported from logbooks divided by spiny standardized effort.

in sublegal CPUE, may increase the legal CPUE and yield, and hence the current levels of fishing may not be as excessive as they first appear at Necker Island.

Considering the yield curves for Necker Island, Maro Reef, and the entire NWHI and the relative female spawning stock biomass levels at Necker Island and Maro Reef, it appears that the current annual landing of about 900,000 spiny lobsters can be sustained. Escape vents appear to be high priority for prudent management.

The combined landings of slipper and spiny lobsters plotted against the logbook reported effort from Necker Island, Maro Reef, and the entire NWHI are given in Figures 6-8. Landings at Necker Island and Maro Reef are lower in 1986 than in 1985. At Maro Reef this decline is due to a reduction in the landing of slipper lobsters, while at Necker Island the decline in 1986 is due to a decline in landings of both slipper and spiny lobsters. At Necker Island the landings of slipper lobsters declined 46% from 154,000 in 1985 to 84,000 in 1986 while the catches of spiny lobsters declined only slightly. Since the fishery for slippers has been intense only since 1985, a decline in landings of slippers in 1986 can be explained as a result of the unexploited stock being fished down. Until the slipper

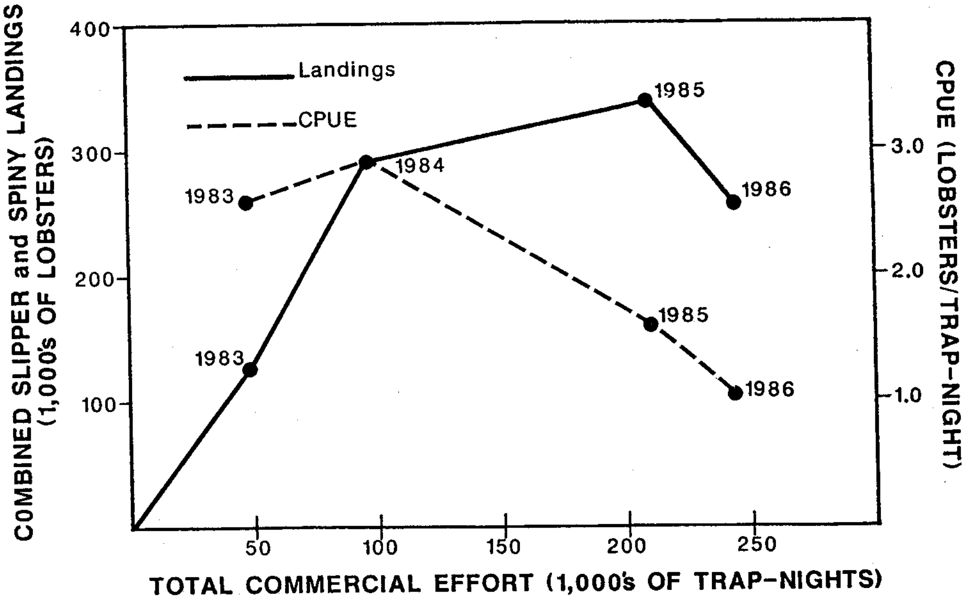

Figure 6.--Landings of slipper and spiny lobster, total commercial effort, and CPUE for Necker Island 1983-86.

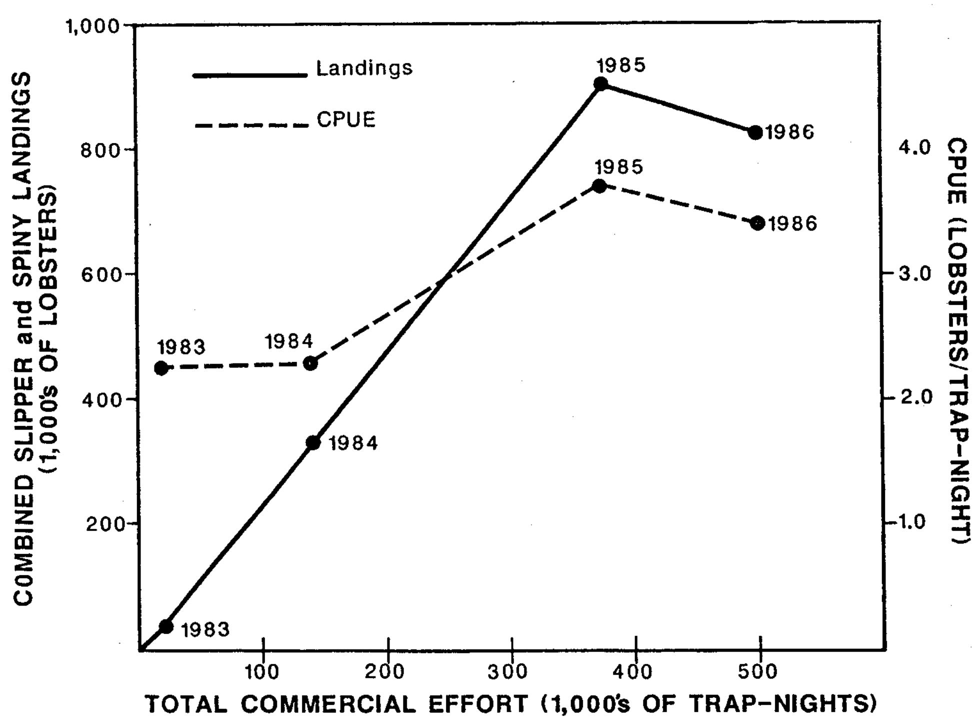

Figure 7.--Landings of slipper and spiny lobster, total commercial effort, and CPUE for Maro Reef, 1983-86.

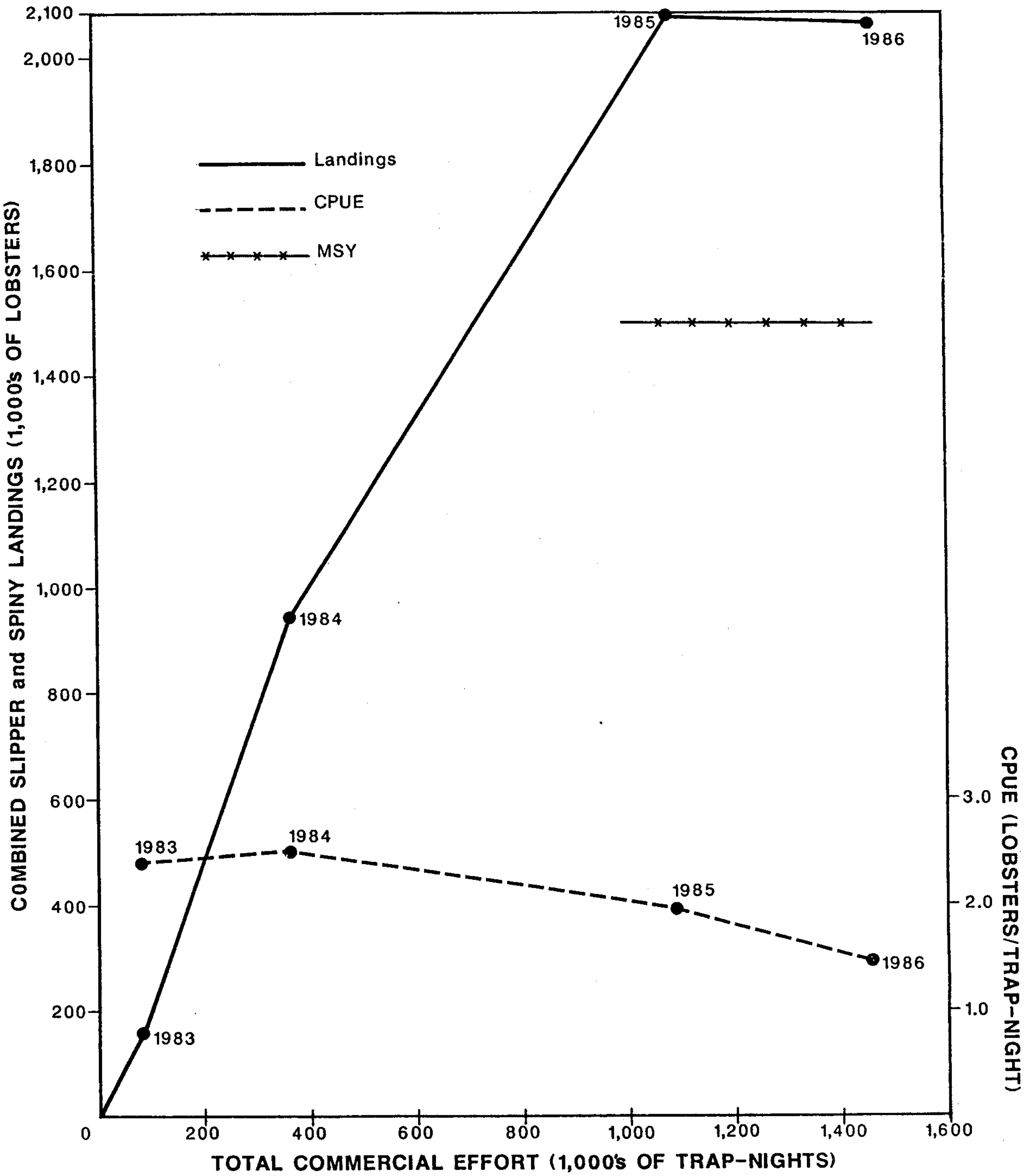

Figure 8.--Landings of slipper and spiny lobster, total commercial effort, and CPUE for NWHI, 1983-86.

landings are more representative of equilibrium conditions and incorporate the effects of a minimum size it will be difficult to estimate optimum fishing effort and yield for the combined slipper and spiny fishery. However, since the yields of slipper lobster in 1985 and 1986 represent the initial exploitation of a previously lightly exploited stock the level of yield can be considered as the product of fishing mortality (F) and the unexploited biomass (B_o). Under equilibrium conditions, at MSY the biomass will be one-half B_o. Thus a first estimate of the MSY for slipper lobsters is the product of F and 0.5 B_o, which if it is assumed that F in 1985 and 1986 is near optimum, one-half of the average annual landings in 1985 and 1986. This approach estimates the slipper MSY at 600,000 lobsters annually. Combining this with the spiny MSY of 900,000 lobsters gives a MSY for the combined slipper and spiny fishery of 1.5 million lobsters annually. In 1986 the spiny and slipper landings were 896,000 and 1,238,000 lobsters, respectively, for a combined landing of 2,134,000 lobsters.